

Improved Convective Scale Prediction from the Assimilation of Rapid-Scan Phased Array Radar Data

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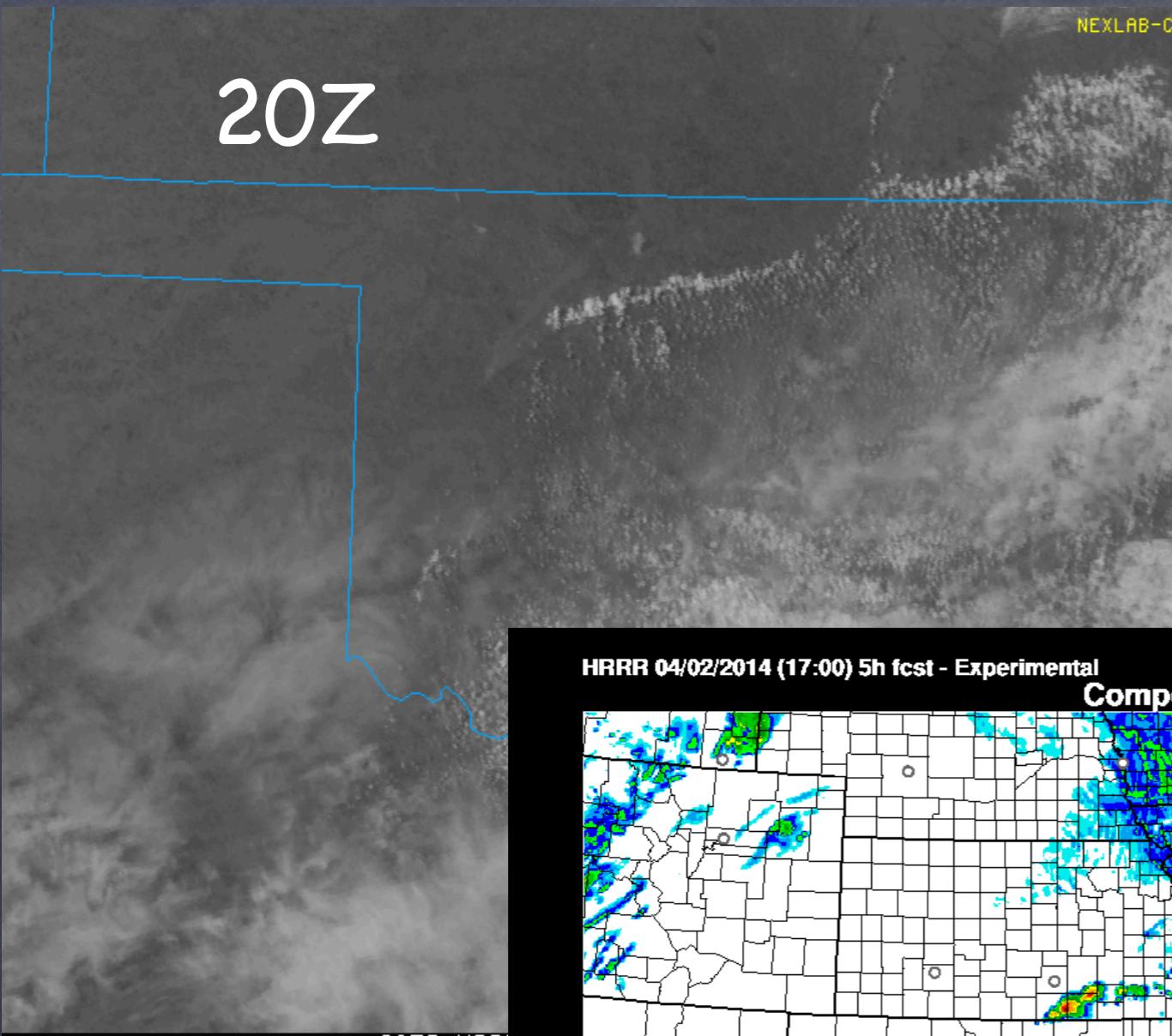


3:06 PM CDT
Last Updated: 3:07 PM

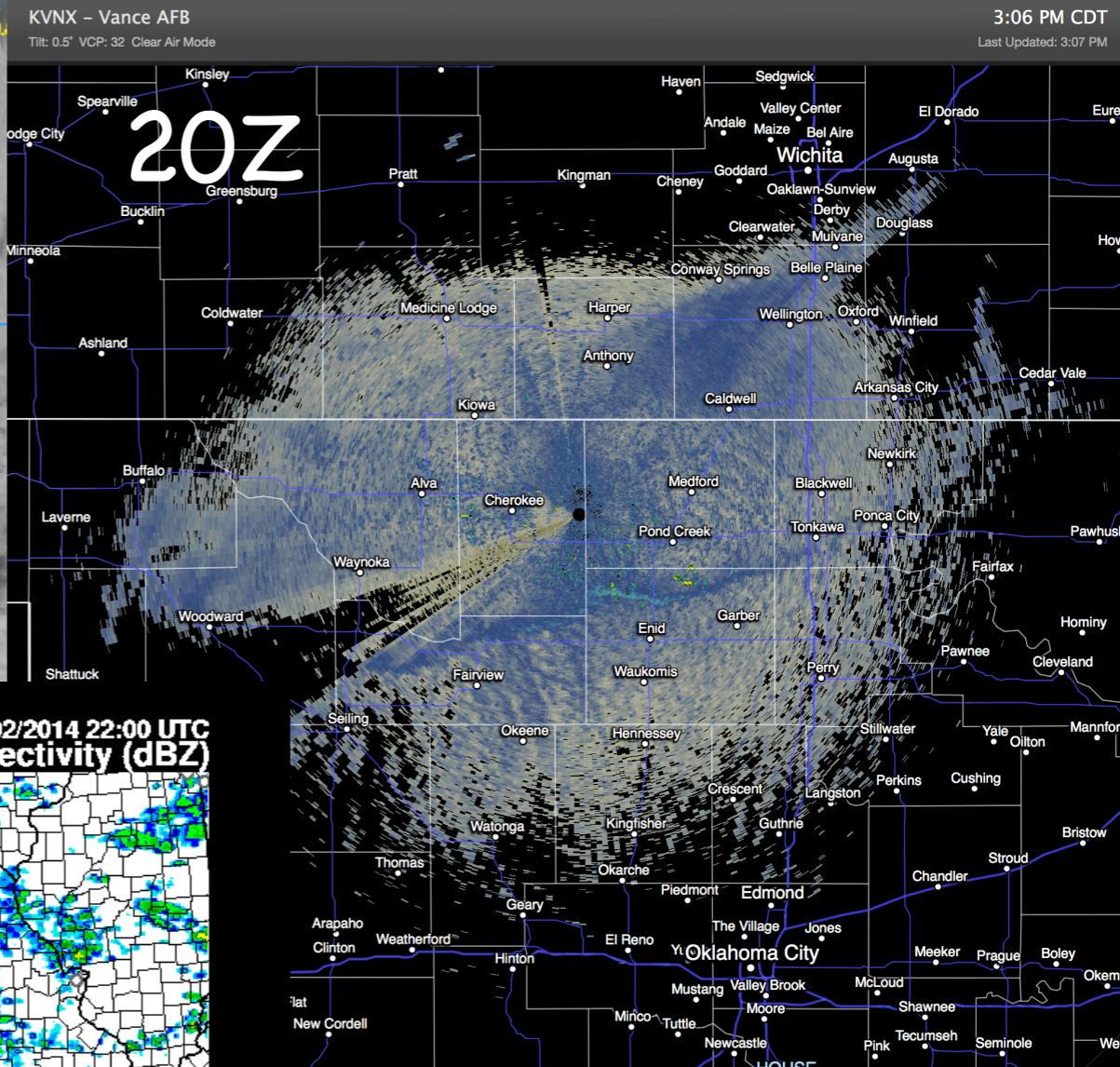
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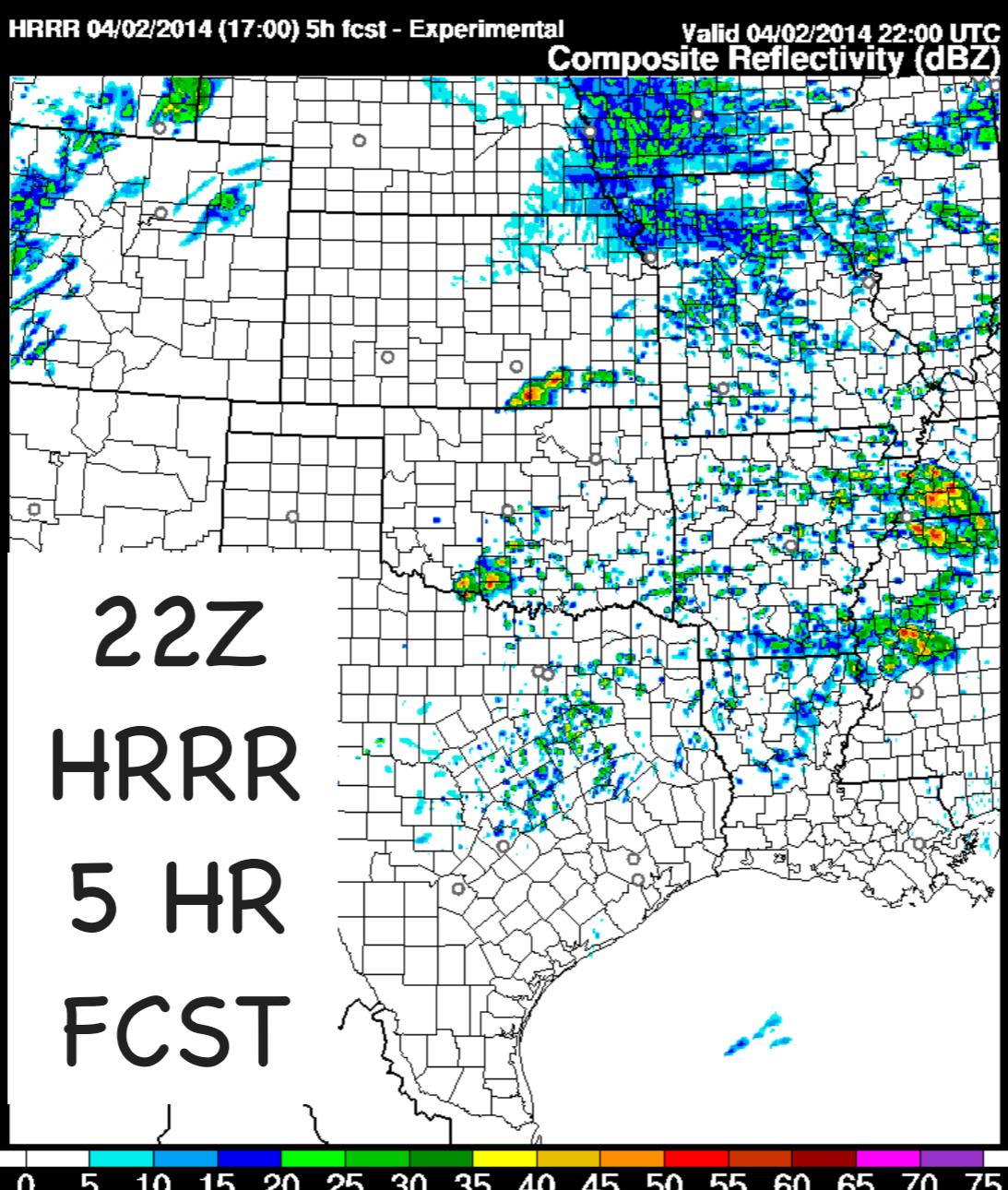
20Z



20Z



22Z
HRRR
5 HR
FCST



National Weather Radar Testbed

Multifunction Phased Array Radar (MPAR)

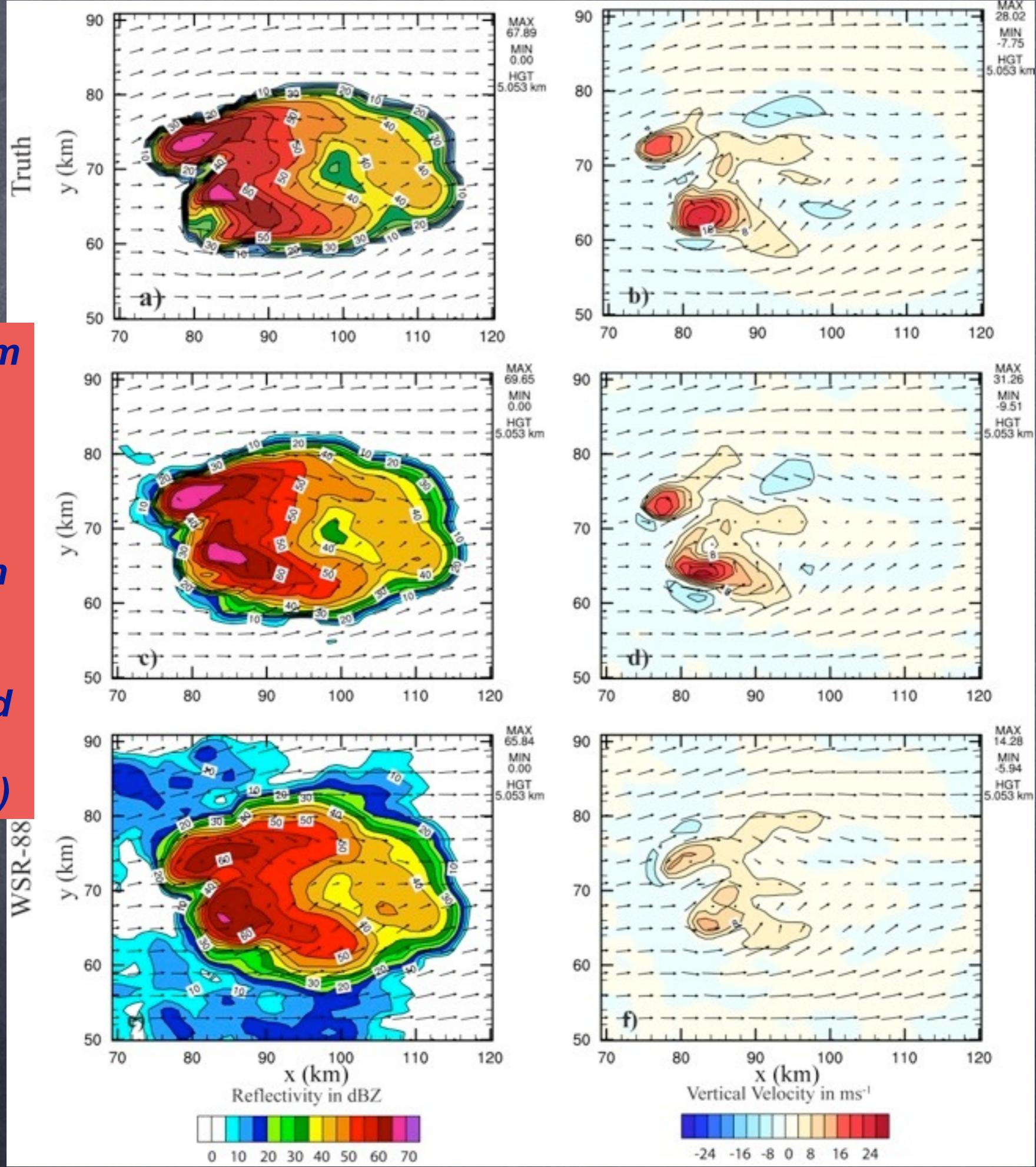


- 9.4 cm single-face phased array antenna
- Forms beam electronically using 4,352 transmit/receive elements
- Completes volumetric scans (of 90° sector) 5-7x faster than WSR-88D
- Beam width broadens from 1.5° at bore-site to 2.1° at a 45° angle

See Forsyth et. al. 2005, Zrnic et. al. 2007, Heinzelman et. al. 2008

**Benefits from
MPAR data
after
15 min of
data
assimilation
(OSSE)**

**Yussouf and
Stensrud
(MWR, 2010)**



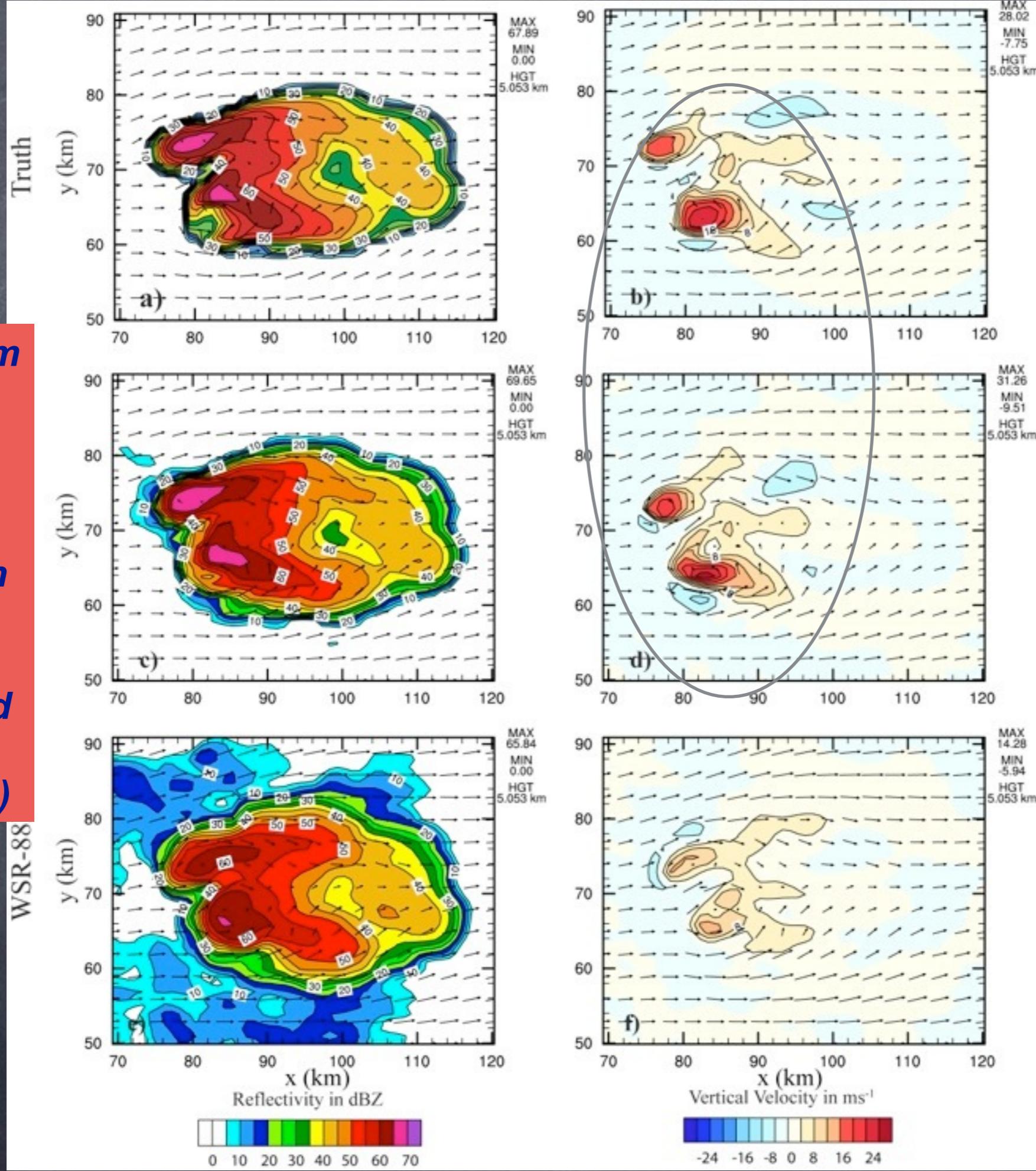
Truth

**PAR
Analysis**

**WSR-88D
Analysis**

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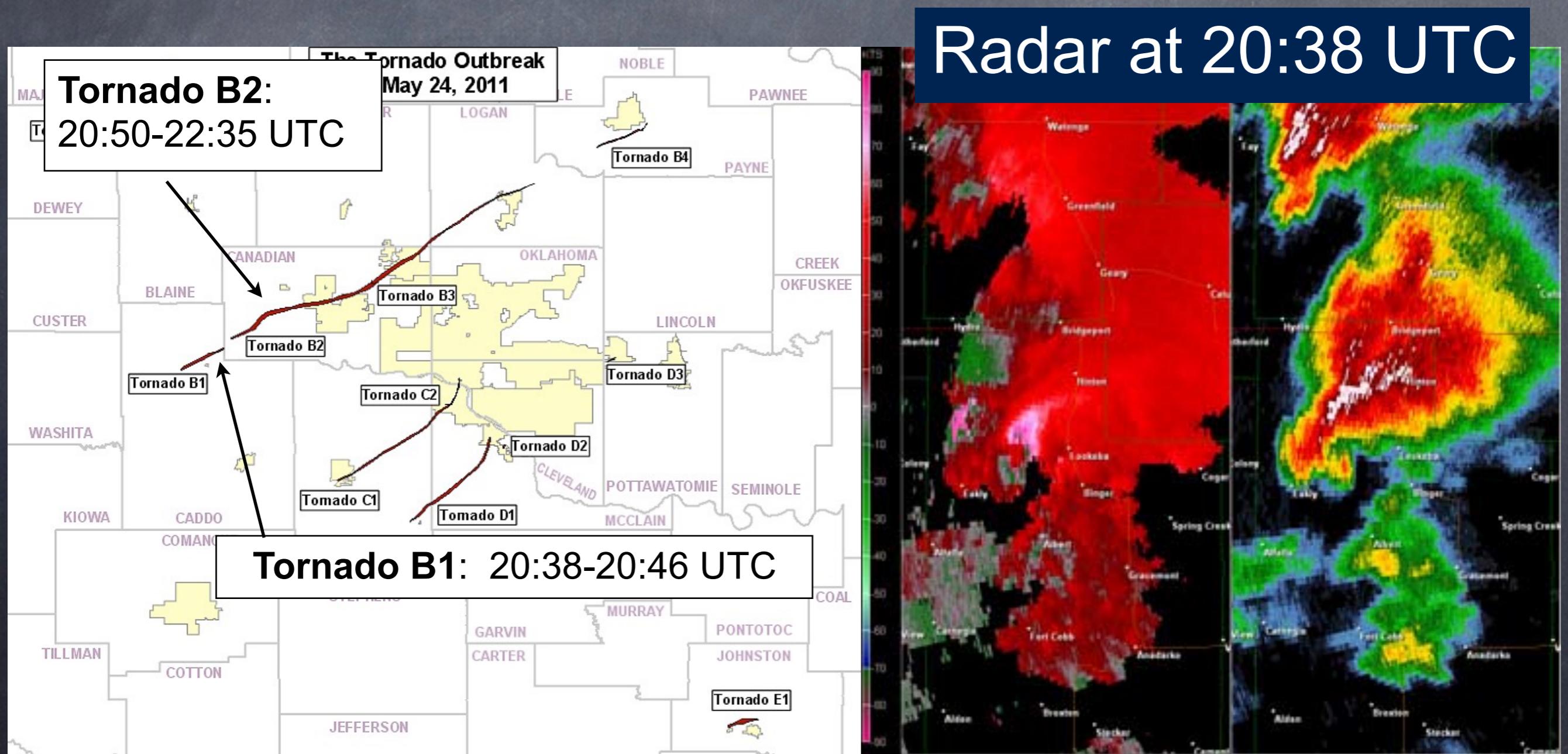
Truth

**PAR
Analysis**

**WSR-88D
Analysis**

Q: Using real MPAR data, will storm-scale NWP forecasts be improved using rapid-scan radar data?

Use the MPAR data set from the 24 May 2011



Technical Stuff

- **Model and ensemble:**
 - NCOMMAS cloud model, 160 km x 160 km 20 km (moving domain)
 - 2 km horizontal resolution with 51 vertical levels ($dz = 250$ m below 2.5 km)
 - Model initialized using 1 hour forecast sounding from operational RUC model
 - Complex microphysics (2-moment scheme, 4-ice class [ice, snow, graup, hail])
 - 48 member ensemble
 - Initial perturbations added to the wind profile in each ensemble member
- **DA System: 4D-LETKF** (T. Thompson et al. 2014 QJRMS)
 - 5 min cycles, +/- 2.5 min temporal window centered on time
 - 9/4.5 km localization cutoff, no temporal localization used
 - Inflation Methodology: Zhang (2004) relaxation to prior perturbation
 - MPAR radar data thinned to 4 km grid on conical surfaces (Dowell et al 2009)

Validation Challenge

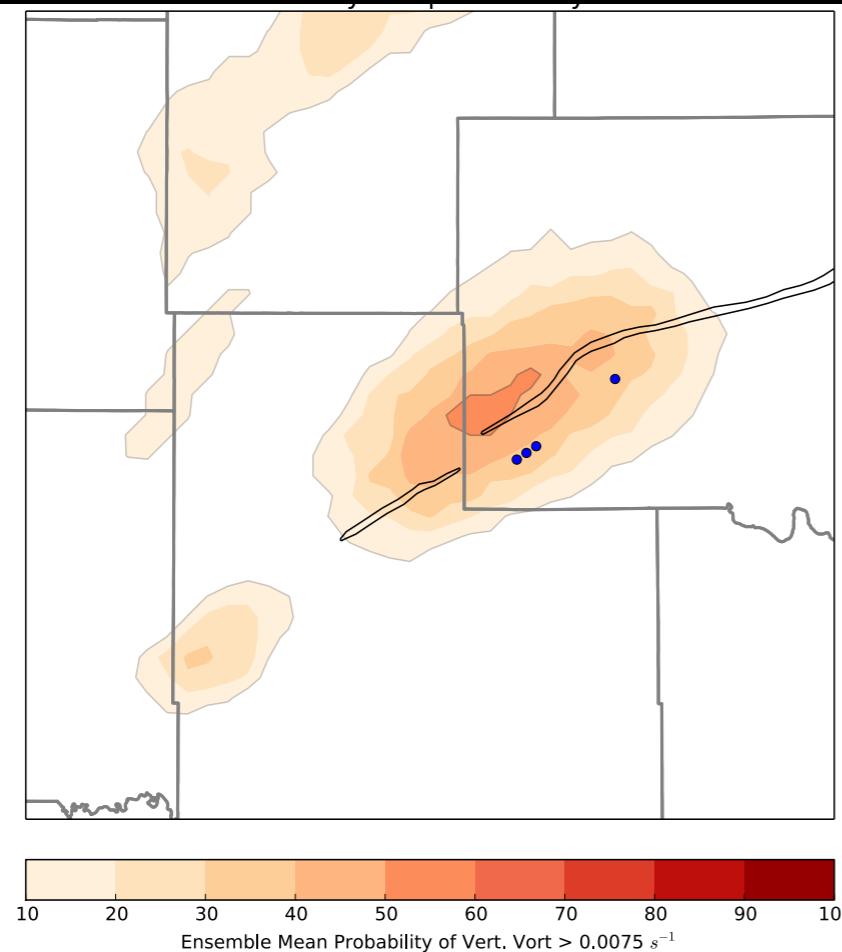
- Problem: How to verify these forecasts?
 - use observed severe weather information
 - forecaster/warning perspective
- Avoid a “tuned” result!
- One Experiment ==
 - two temporal frequencies of radar data
 - 1 minute volumes (actual MPAR data collection)
 - 5 minute volumes (approximating the WSR-88D)
 - 6 forecasts generated for experiment
 - after 10,15,20,30, and 40 minutes of data assimilation
 - forecasts to same time
- More than dozen experiments run

Examine Two Questions...

- **Do 1 minute volumes spin up faster?**
 - Short assimilation cycles (10-20 min)
 - Will 5x more data make up for this relative to the conventional radar data?
- **Do 1 minute volumes continue to add value later?**
 - For longer assimilation cycles (30 min)
 - Will 5x more data continue to improve the forecasts?
- **One Experiment shown**
 - Initialization at 19:40 with reflectivity-based perturbations
 - Ensemble “cooks” for 20 minutes, radar DA begins at 20:00
 - Show 30 minute forecasts from 20:10, 20:20, 20:30

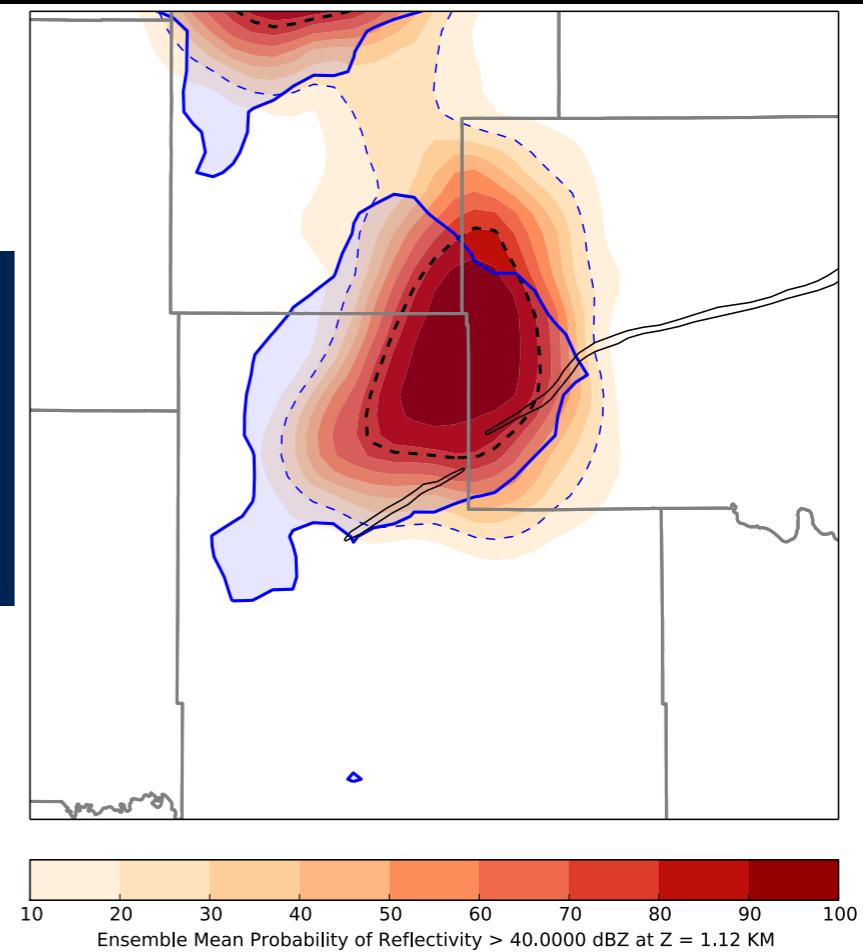
After 10 min of radar DA: Does ensemble using 1 minute data spin-up quicker?

**0-1.5 km Mean Layer Rotation
Forecast 20:10-20:50 UTC**



**88D
3
Volumes**

**1 km Reflectivity
Forecast valid @ 20:30 UTC**



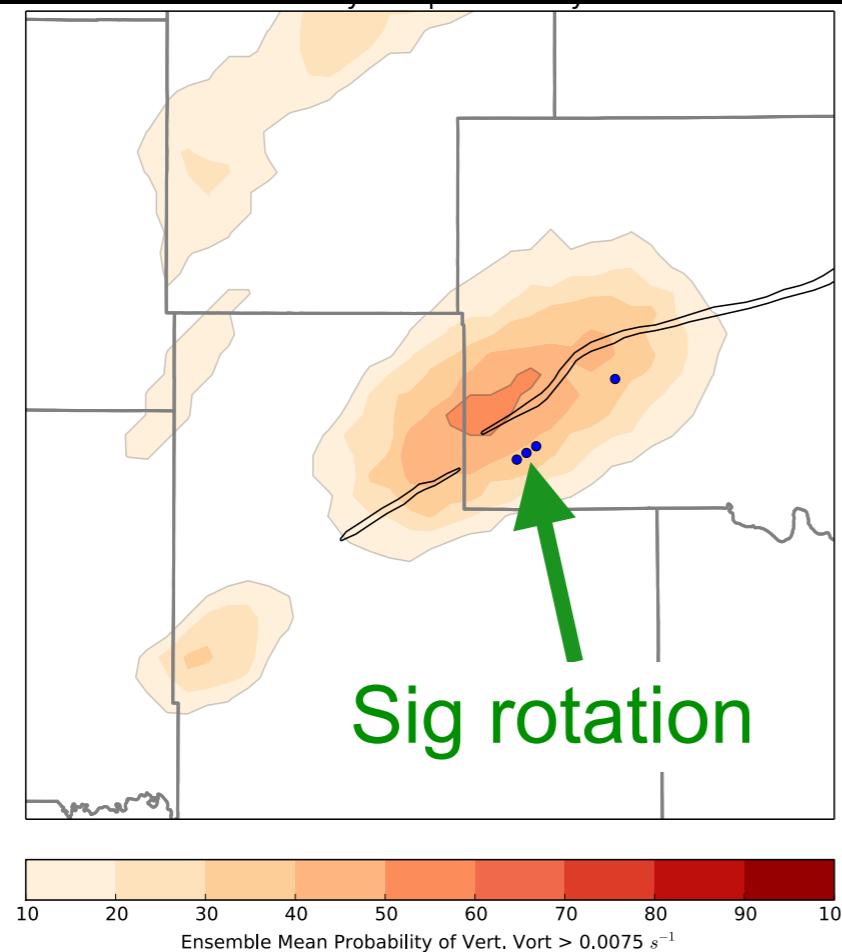
Shaded regions: $\text{Prob}(\zeta > 7.5 \times 10^{-3} \text{ s}^{-1})$

Blue dots: members where $\zeta > 1.5 \times 10^{-2} \text{ s}^{-1}$

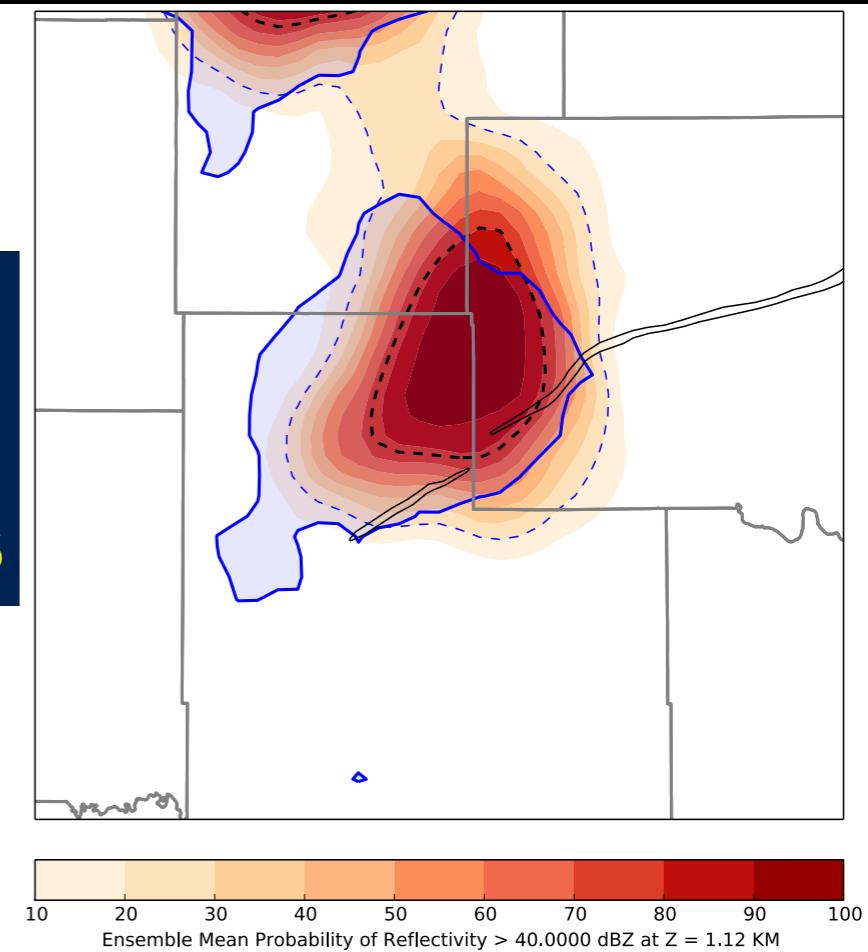
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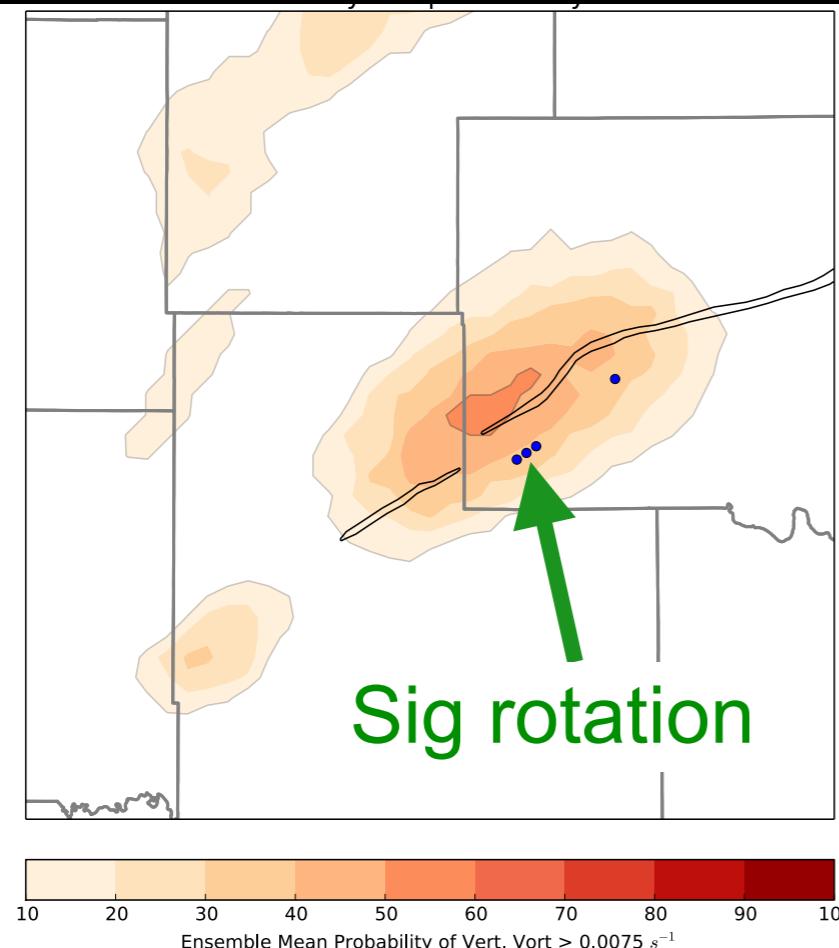
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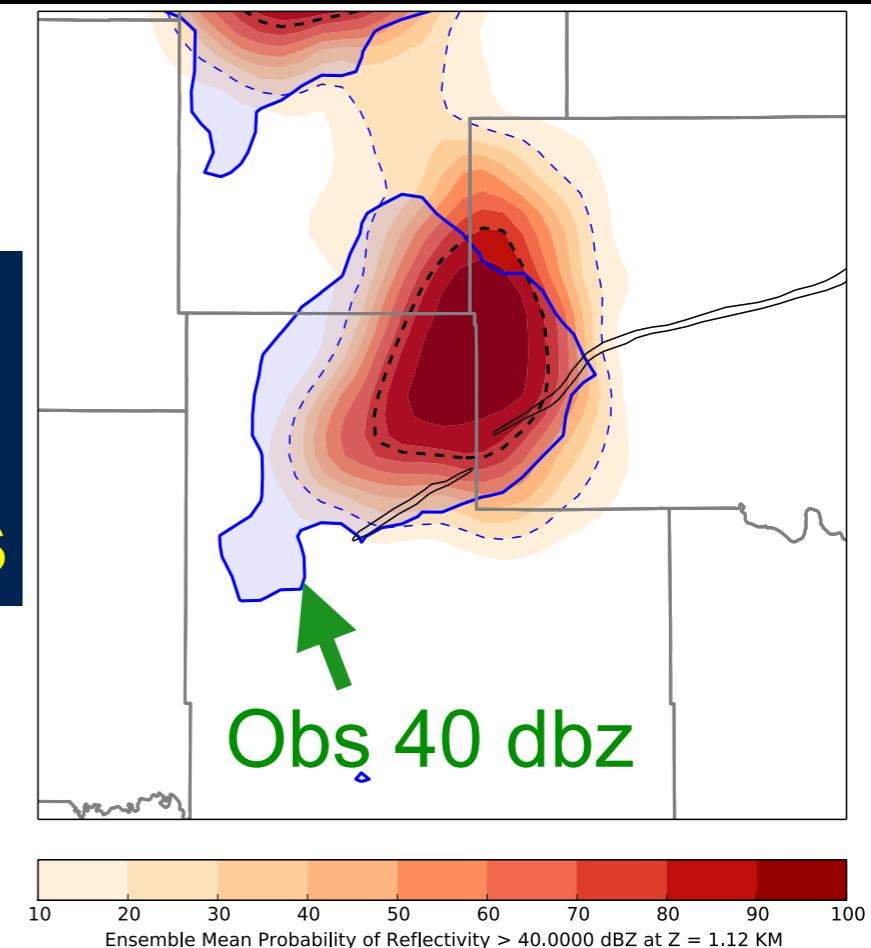
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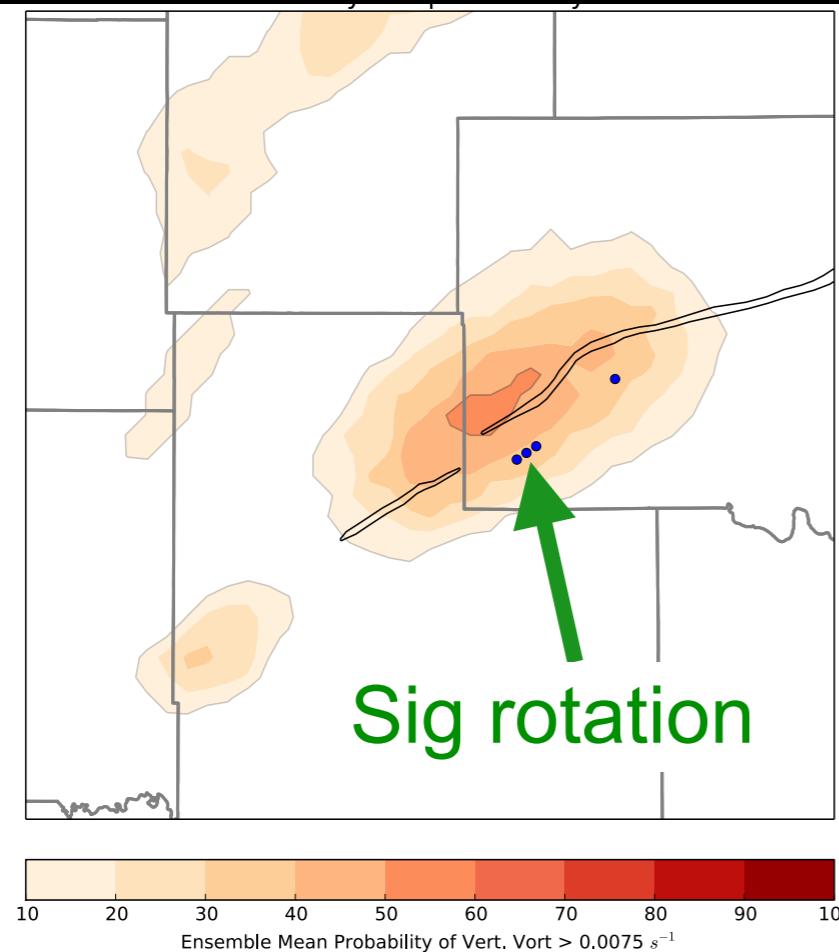


**88D
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Volumes**

Obs 40 dbz

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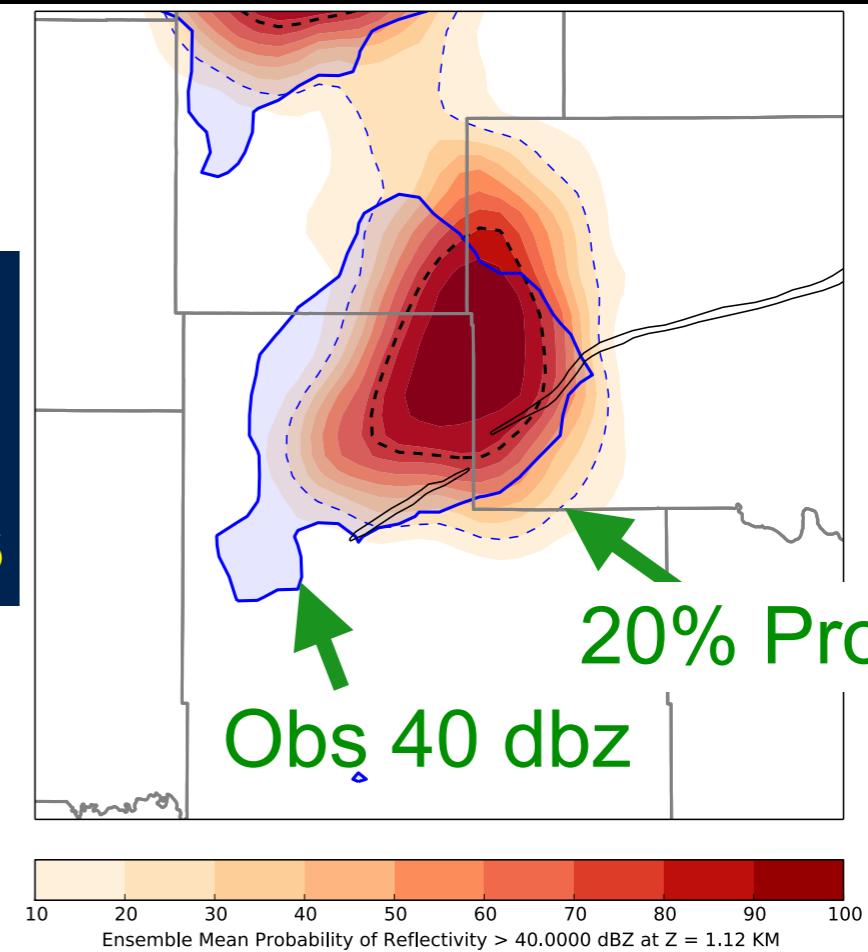


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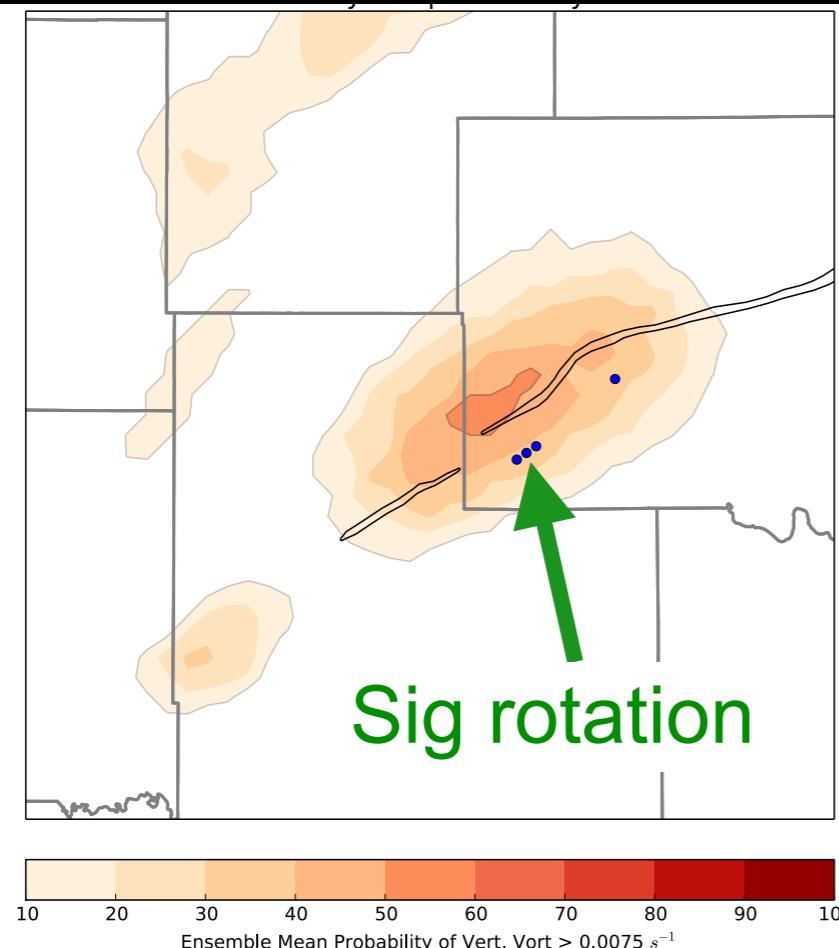
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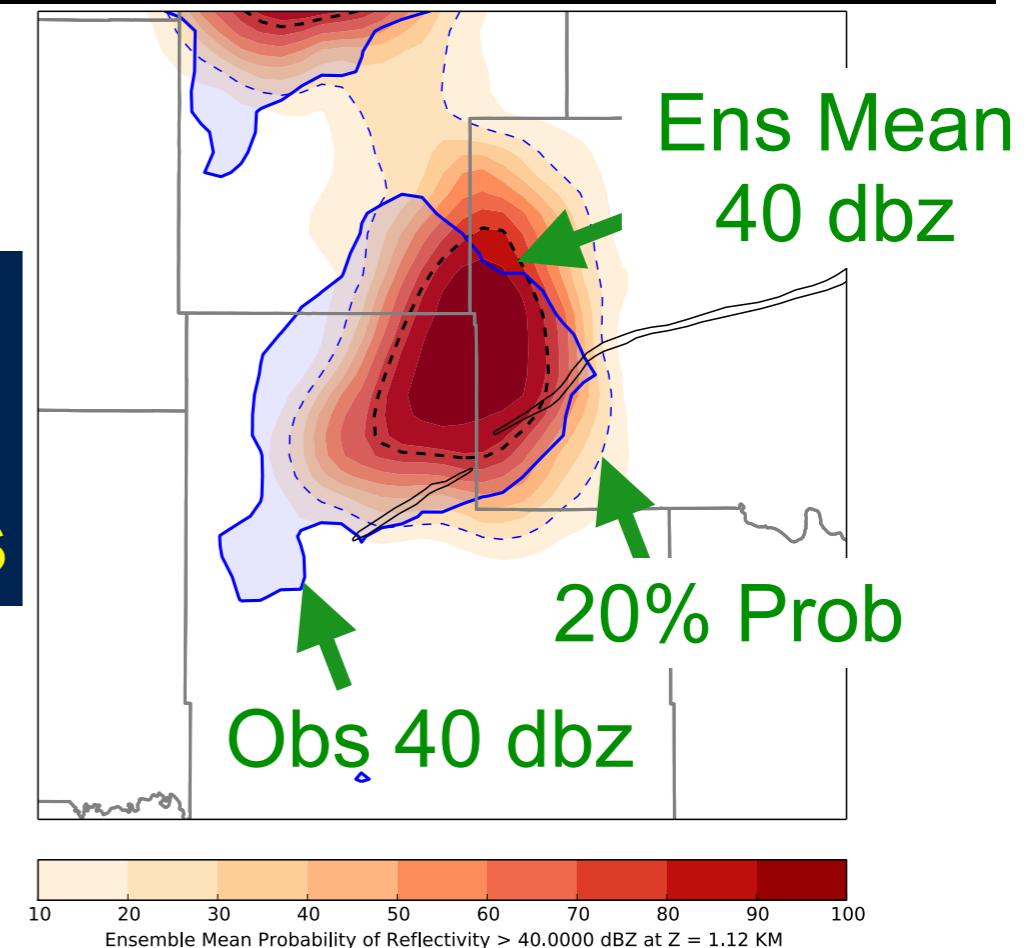
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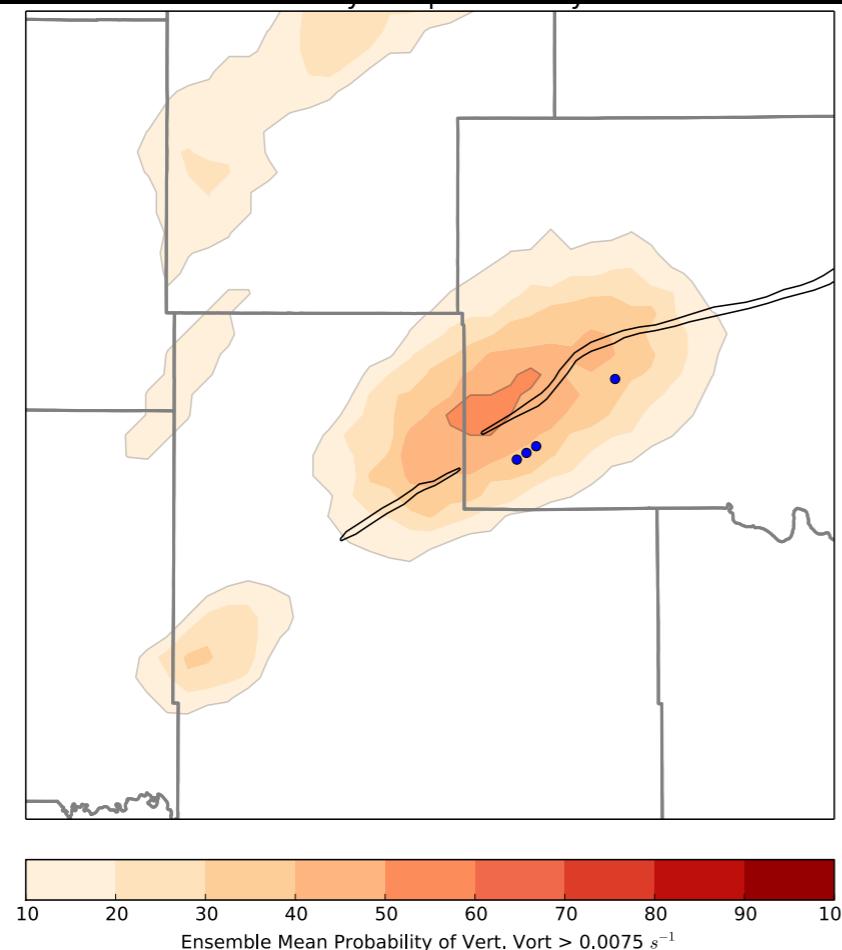
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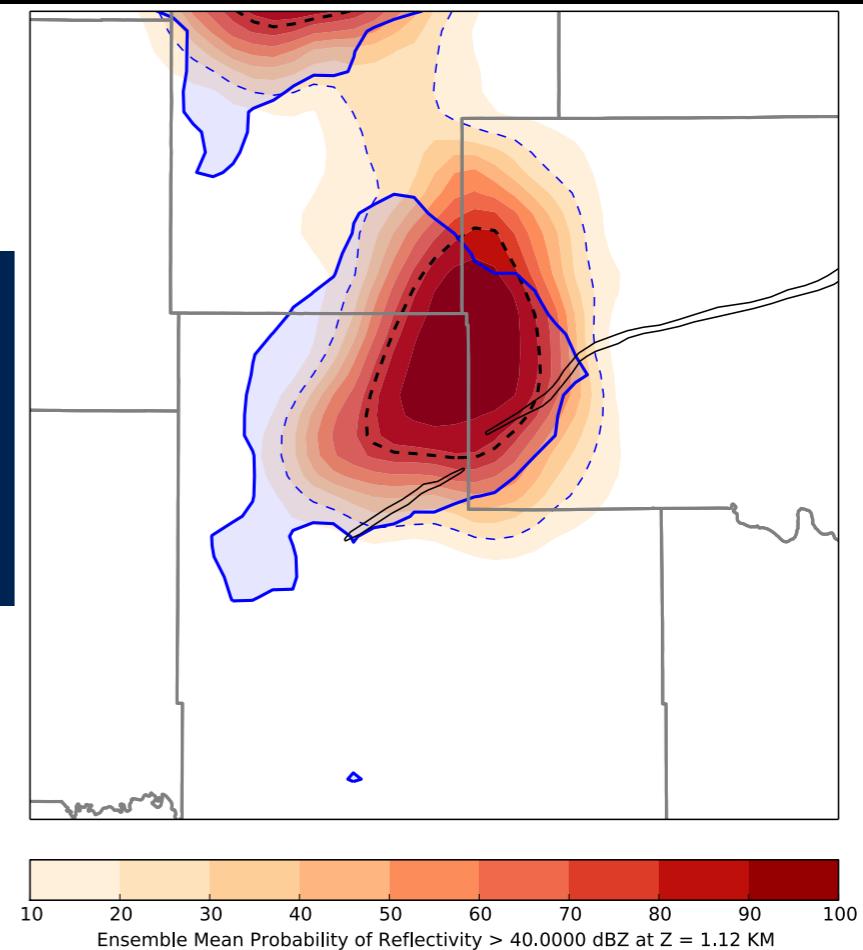
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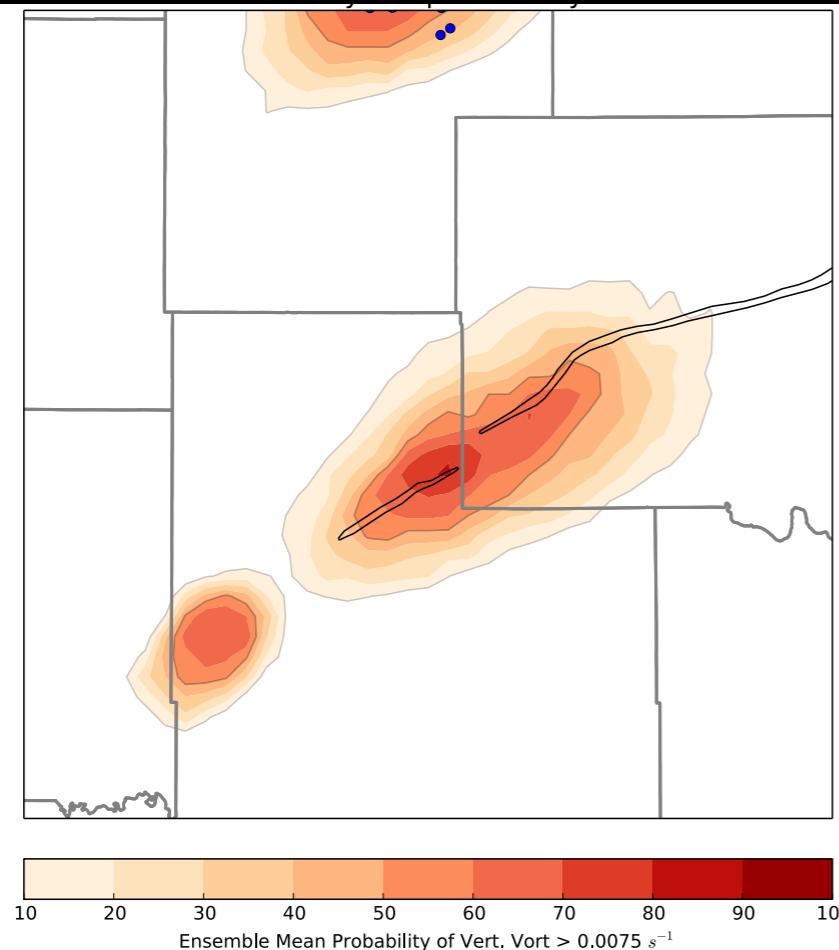
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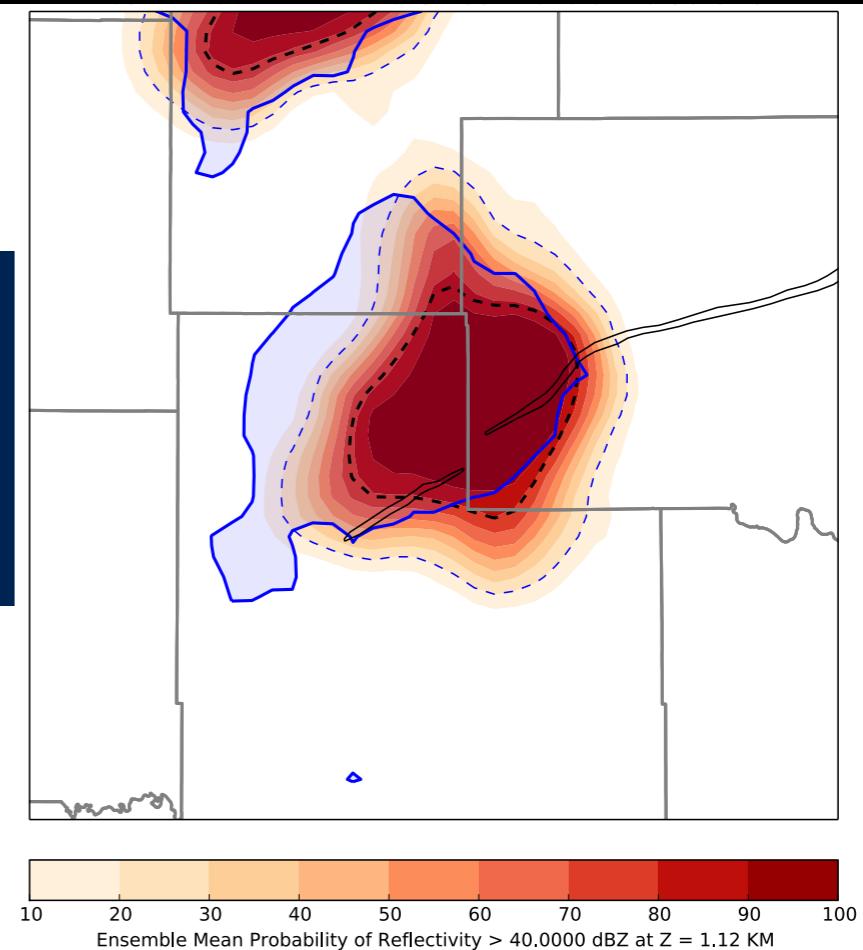
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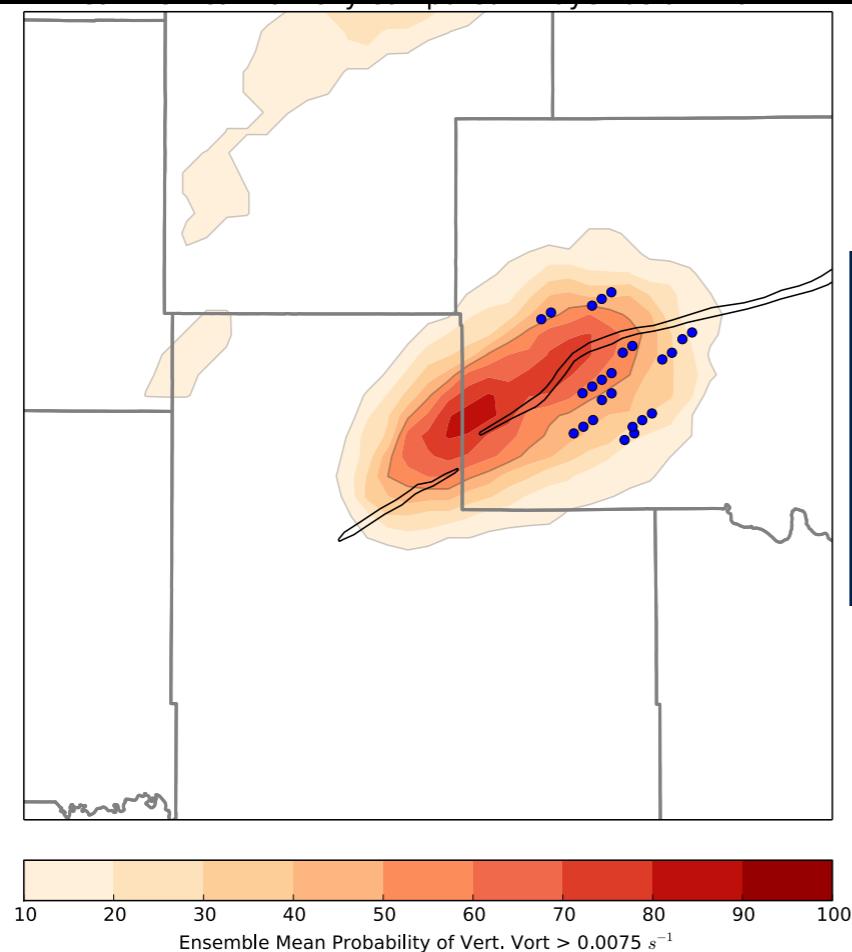
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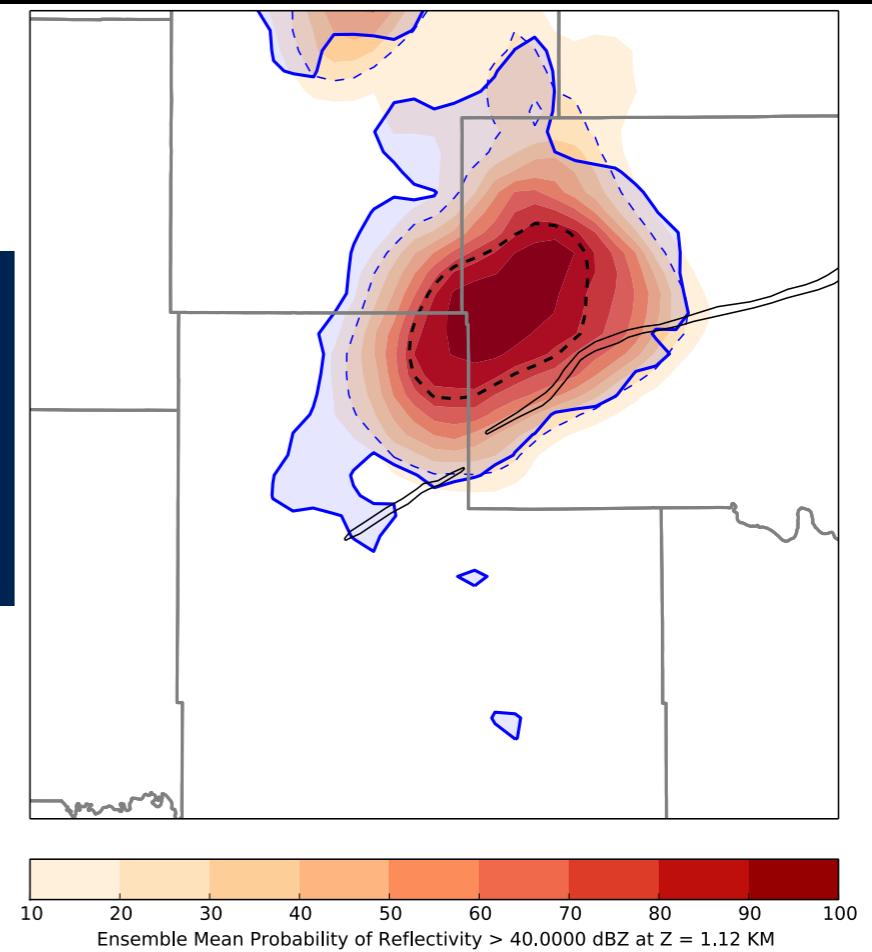
After 20 min of radar DA

**0-1.5 km Mean Layer Rotation
Forecast 20:20-20:50 UTC**



**88D
5
Volumes**

**1 km Reflectivity
Forecast valid @ 20:40 UTC**



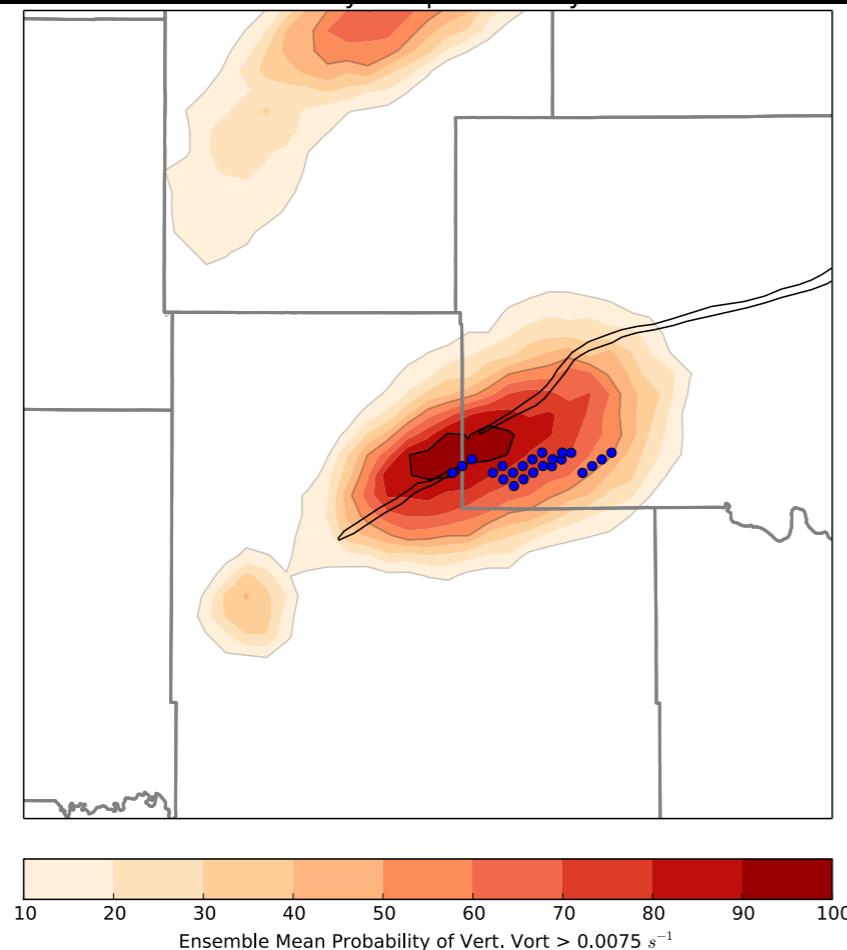
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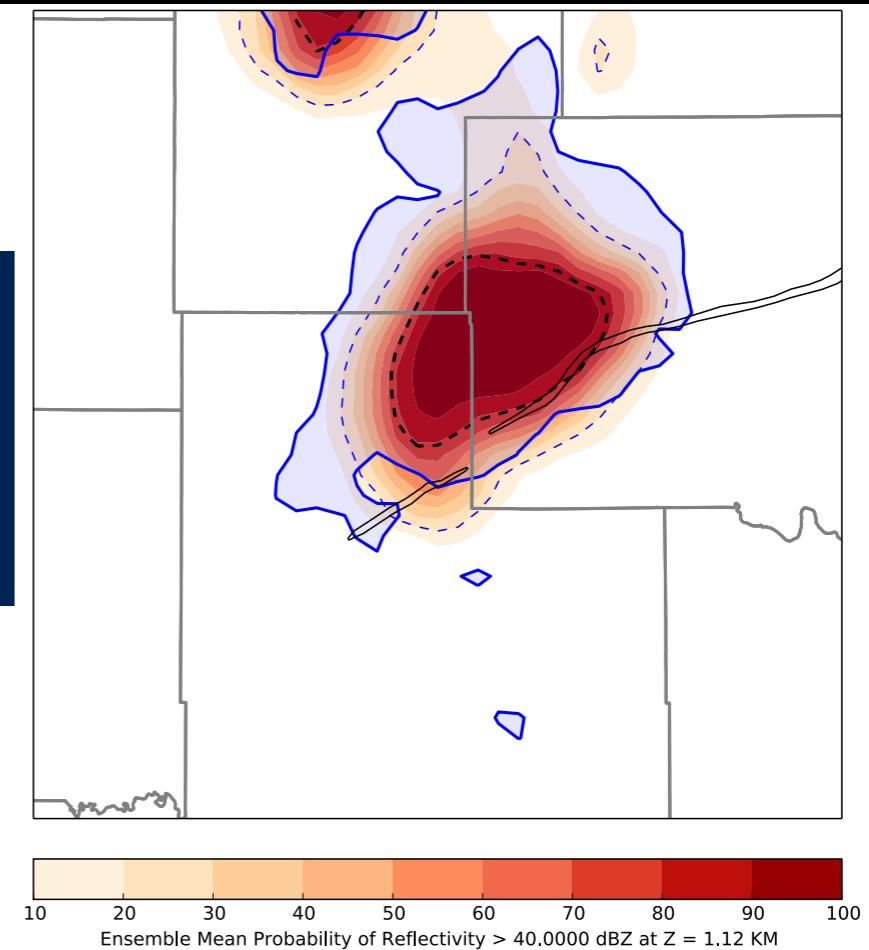
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After 20 min of radar DA

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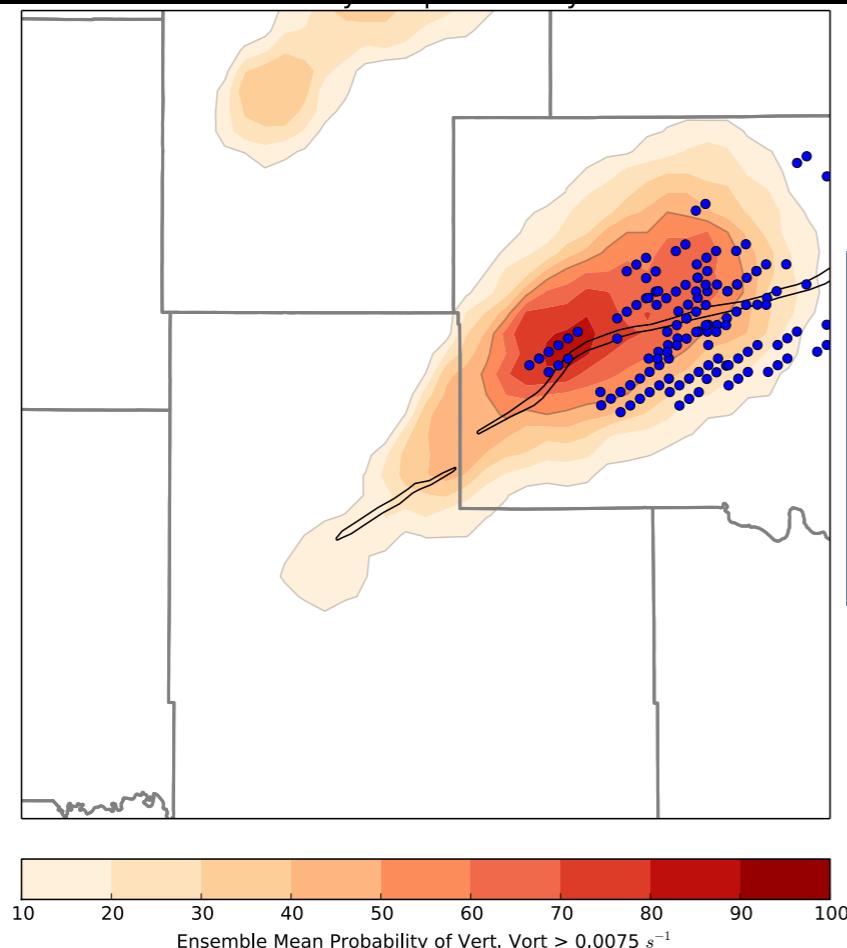
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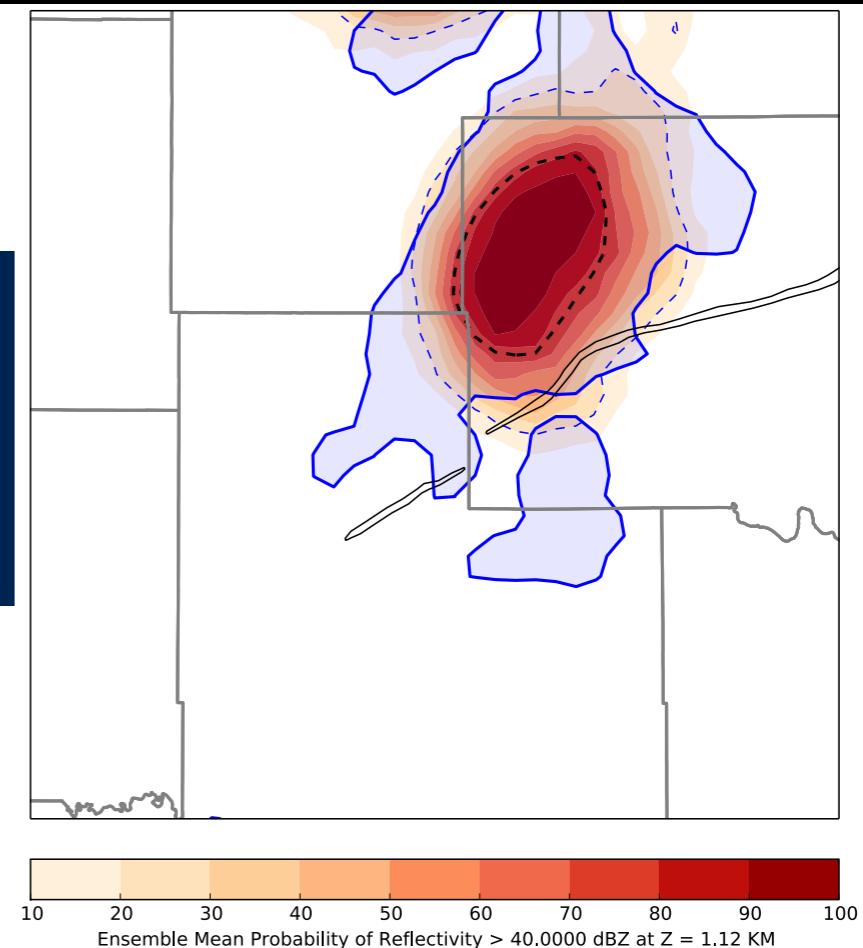
After 30 min of radar DA: Do 1 minute volumes still improve forecast?

0-1.5 km Mean Layer Rotation
Forecast 20:30-21:00 UTC



88D
7
Volumes

1 km Reflectivity
Forecast valid @ 20:50 UTC



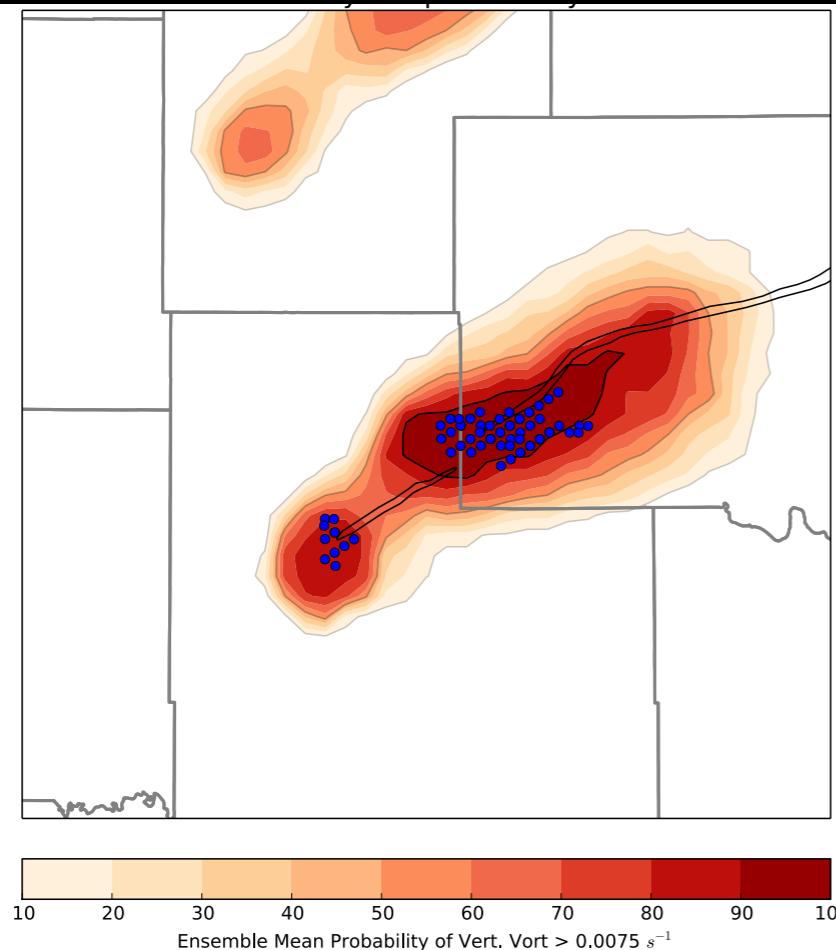
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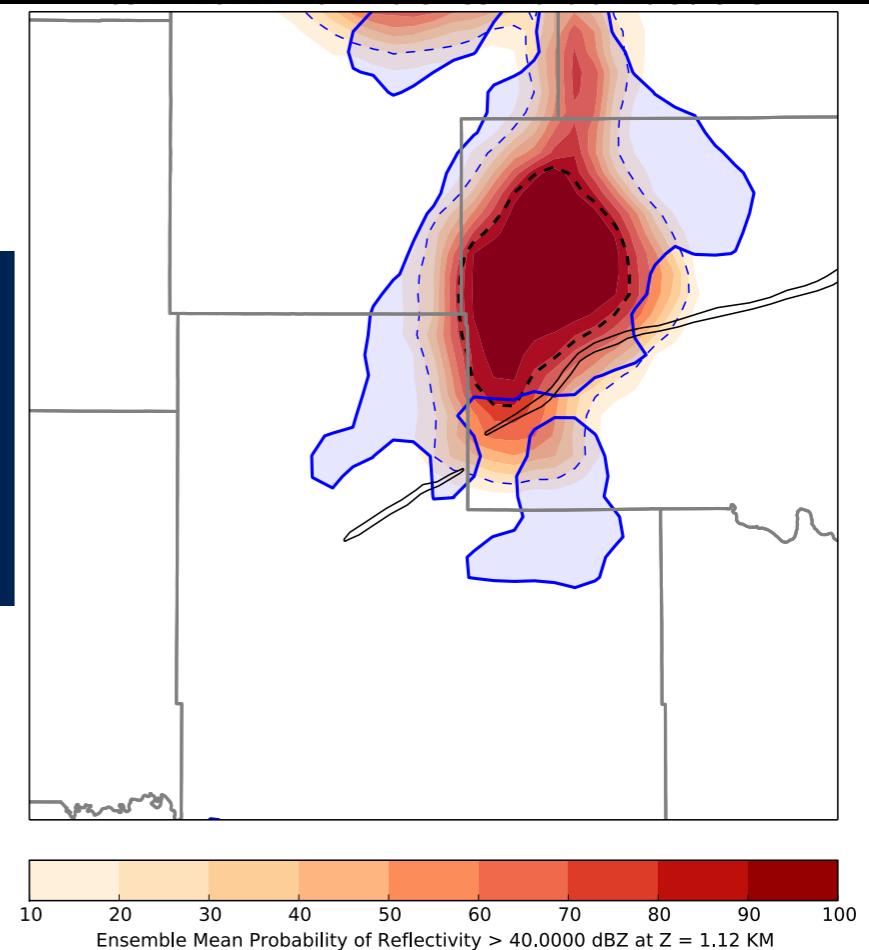
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Summary

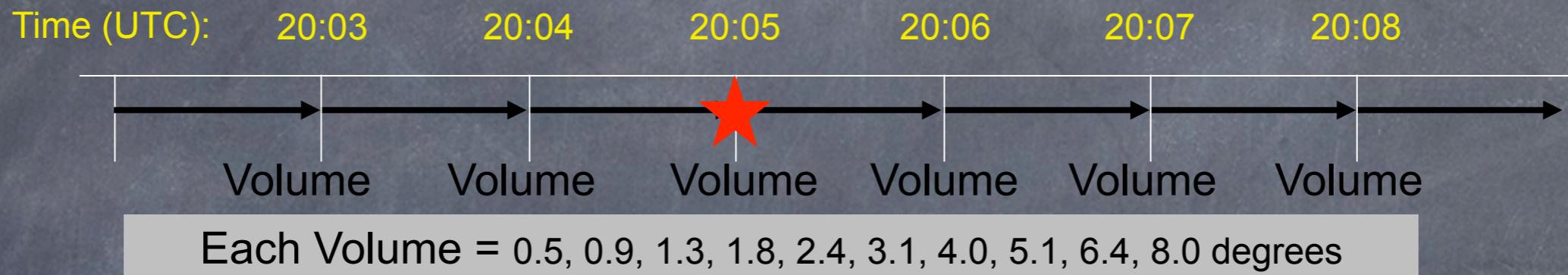
- Results are similar to Yussouf & Stensrud's OSSE
 - **1 minute volumes spin storm up faster**
 - **1 minute volumes continue to improve forecasts even after 30 minutes**
- Other experiments (not shown) are consistent with these results (different superob density, different initialization periods, KTLX radar DA for 20 min before 20:00, etc.)
- Assimilation of 1 minute data synchronously (e.g., every minute) is very sensitive to data density and other assimilation parameters. Inconsistent results are found.
- ***Storm-scale NWP will likely greatly benefit from a next-generation radar network having rapid-scan capability.***

Radar Data

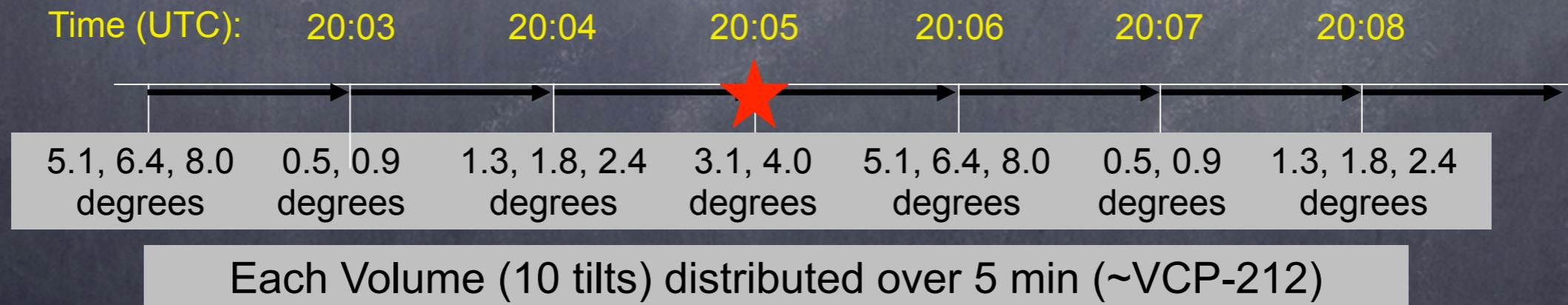


- 4D Asynchronous LETKF
- 1) run 5 min forecast
- 2) assimilate radar data
- 3) run next 5 min forecast

1 min volumes



5 min volumes

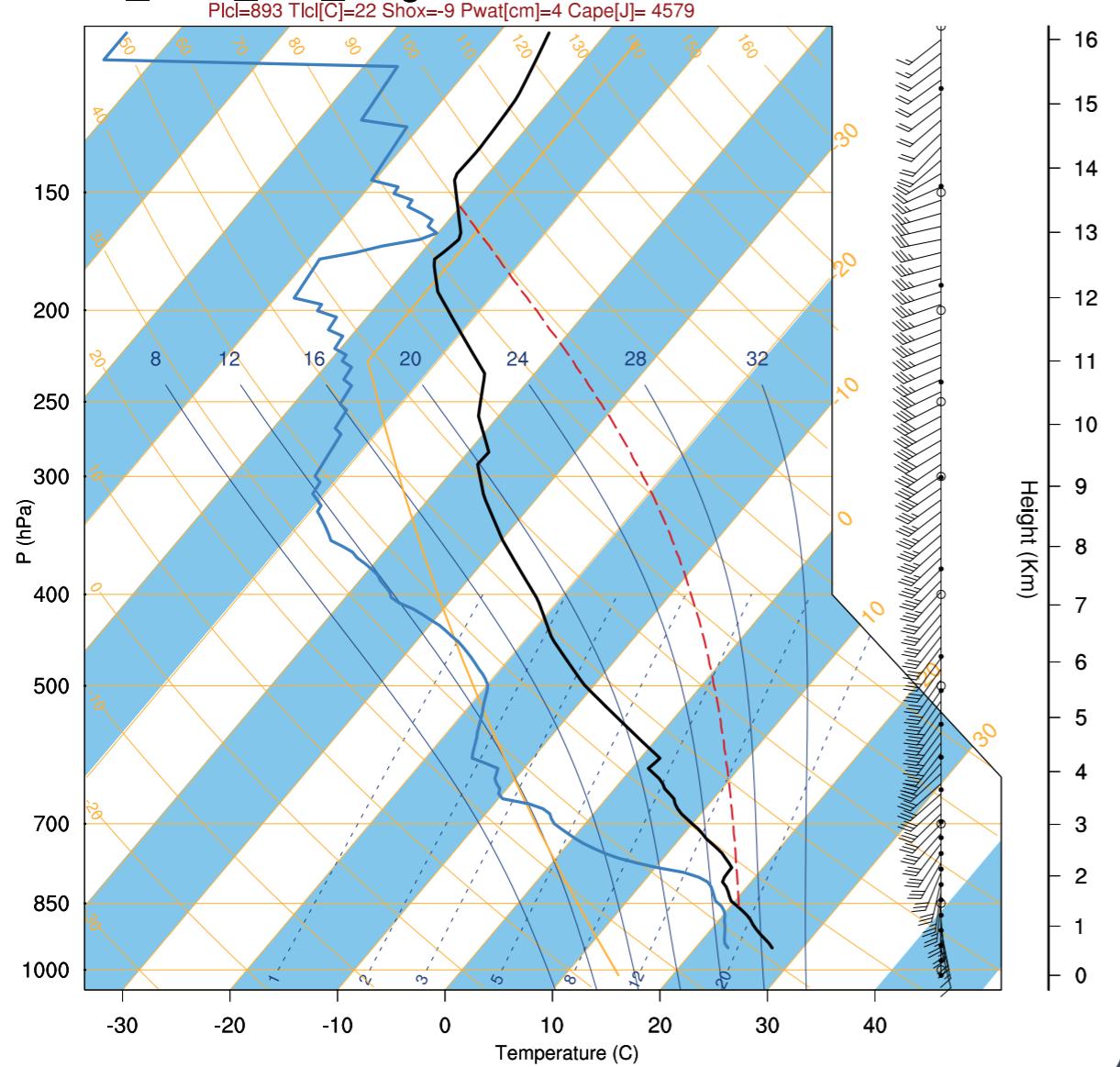


ONLY PAR data is used to examine impact from rapid-scan capability

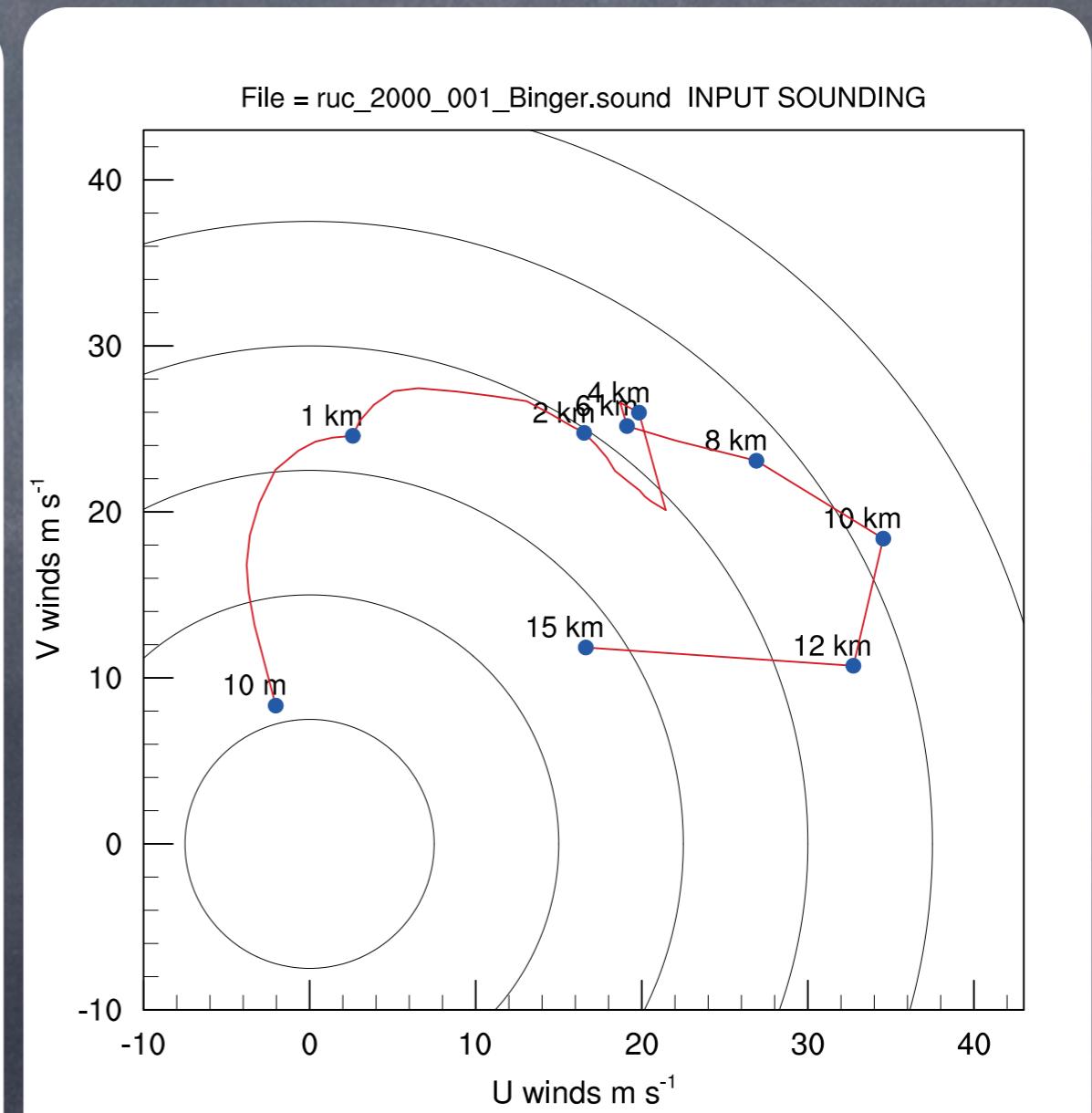
Background Mesoscale Environment

- Assumption: In tornado outbreaks the warm sector is more homogeneous than in other situations? (else you would not have an outbreak....)
 - homogeneous background environment (HBE) is sufficient for basic radar DA research
 - HBE reduces computational cost considerably (enables many more tests)

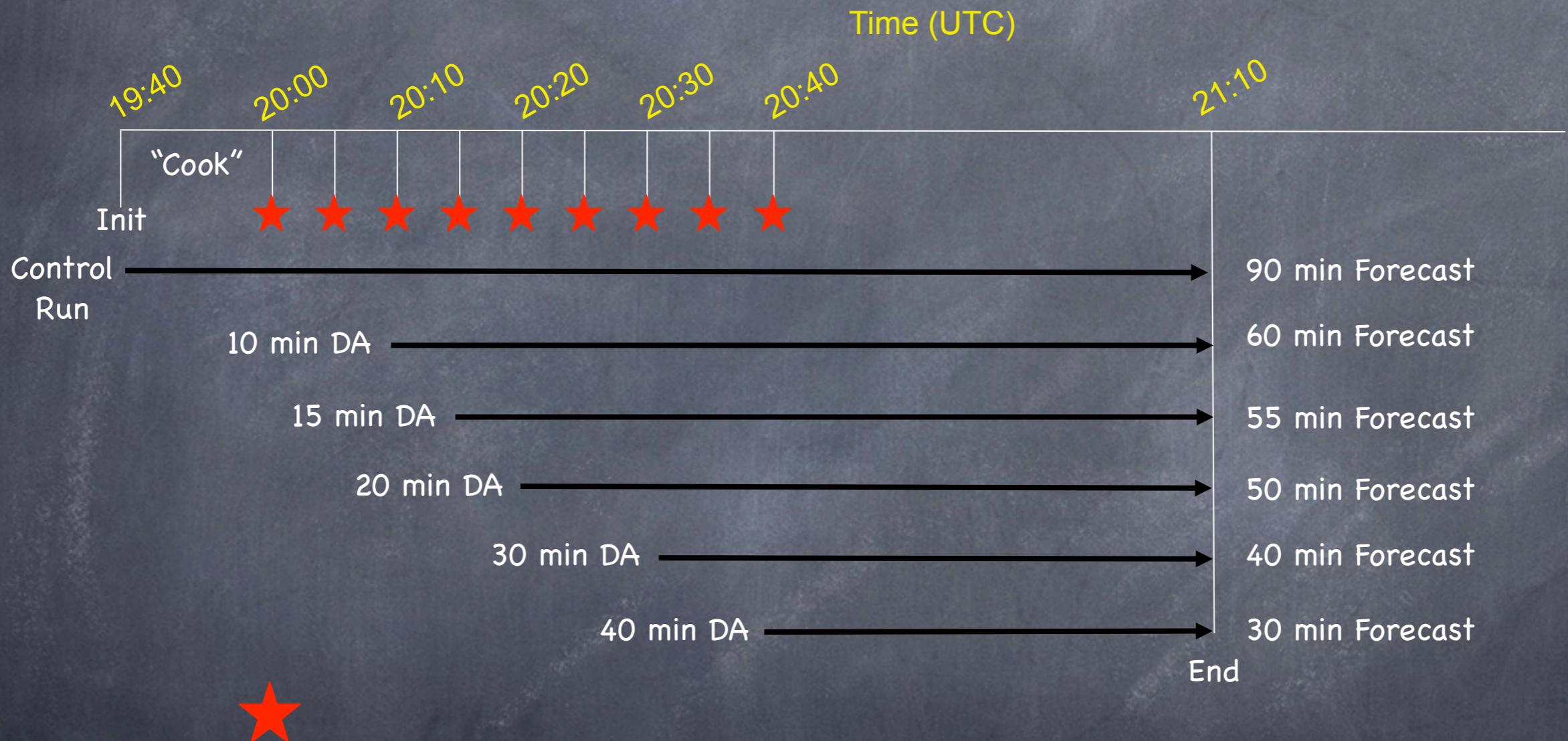
File = ruc_2000_001_Binger.sound INPUT SOUNDING



File = ruc_2000_001_Binger.sound INPUT SOUNDING



Data Assimilation & Ensemble Forecasts



4D Asynchronous LETKF

- 1) run 5 min forecast
- 2) assimilate radar data
- 3) run next 5 min forecast

6 forecasts

Control Run: Shows improvement from radar DA